DEVELOPMENT OF COMPLEX ANTIOXIDANT FOR ATHLETES

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Abstract: Sport of higher achievements requires hard training from athletes in a hard time mode for many years. Therefore, it is very important to monitor the diet of athletes. The aim of this research is development of a complex herbal antioxidant that can be used to increase the quality of the oils, fats and fat-containing products included in the diet. The current state of the use of antioxidants is assessed. The features of plant and synthetic antioxidants are described. The development of antioxidant is carried out from such plant materials as walnut leaves and calendula flowers. The chemical composition of the active antioxidant substances of walnut leaves and calendula flowers is given. The methods used in the work are aimed at obtaining extracts, estimating rational extraction parameters, and testing the antioxidant abilities of the extracts from periods of induction of products with different fatty acid composition. It is also used to plan and process the results of a full factorial experiment, to develop a technology for stabilizing fat-containing products to oxidation processes. It is proved that the developed complex antioxidant can increase the stability of food products to oxidation processes, protecting the product from the accumulation of free radicals. The rational parameters of the process of extraction of antioxidant substances from the studied plant materials are indicated. Data from induction periods, by which the quality of the extracts was assessed, is obtained using the Oxy test device. Synergism between tocopherols and antioxidant substances of walnut leaf extracts and calendula flowers is studied. The effectiveness of the antioxidant in relation to the products of different fatty acid composition is shown, which gives the right to use the antioxidant in a wide range of fat-containing products. A scheme for the stabilization of vegetable oils by the developed antioxidant is proposed. Recommendations on the enrichment of the diet of athletes by developed antioxidant are given.

Keywords: vegetable antioxidant, nutrition of athletes, induction period, free radicals, fat-containing products.

1. Introduction

Sport of higher achievements requires athletes to train on the edge of human capabilities. The result of an athlete is influenced by the level of physical and psychological fitness, daily routine, nutrition, and a number of other factors. Due to the great influence on the training and competitive process of athletes nutrition, issues related to the development of substances to enrich the diet of athletes, is an important task.

Antioxidants are substances that are able to convert free radicals into stable molecules, as well as slow down the processes of free radical oxidation. This is important because free radicals can destroy the cells of the body. Under physiological conditions, free radicals are constantly formed in the body in small quantities. And the antioxidant enzyme systems of the body are involved in their neutralization. In athletes, the rate of formation of free radicals is increased. This is due to the presence of large physical and emotional stress [1]. It is known [2] that during the processes of tissue respiration along the respiratory chain of mitochondria four hydrogen atoms are transmitted to the oxygen molecule. If not four hydrogen atoms are transferred, but less, then free radicals are formed instead of endogenous water. Such process can occur with abrupt changes in the intensity of the load, which is particularly active in acyclic sports. Due to the fact that an increased amount of free radicals is formed in the body of athletes, the introduction of exogenous antioxidants is necessary to protect the cells of the body of athletes. Exogenous antioxidants are those that come from food. Food from which antioxidants come can be divided into two categories: food products entering the body in unchanged natural form (fruits, vegetables, nuts, etc.); products obtained during manufacturing operations (for example, vegetable oils, confectionery, etc.).

As for the first group. Many antioxidants are present in plant foods [3–8]. As for the second group. To protect against oxidation of the lipid components of such products, antioxidants are introduced into the composition of the products. In this case, antioxidants are used natural and synthetic. Of the synthetic ones, butylhydroxytoluene and butylhydroxyanisole are especially widespread. They are widely applicable due to the relatively (compared to natural) low cost. However, the use of synthetic antioxidants is not rational from the point of view of food hygiene [9, 10]. The use of natural antioxidants is more rational, since natural antioxidants are not only safe for health, but also useful [11, 12]. To date, there is a large amount of research aimed at the development of plant antioxidants. However, many of them are expensive. For example, an antioxidant from an apple will be expensive, since an apple can be sold for a high price anyway. If to make an antioxidant from an apple, then the price will increase from the value of the apple. Therefore, the aim of this research is development of a natural antioxidant derived from plant materials, which does not directly enjoy wide consumer demand.

Tasks that need to be solved to achieve the aim: choice of plant materials; determination of technological parameters of extraction for the extraction of antioxidants from plant materials; checking the antioxidant abilities of the obtained plant extracts; development of recommendations for the stabilization of food products obtained with antioxidants; drawing up recommendations on the enrichment of the diet of athletes with developed antioxidants.

2. Methods

The main substances used in the work are: walnut leaves, calendula flowers, distilled water, ethyl alcohol, citric acid, activated carbon, glycerin, azoisobutyronitrile, xylene, sunflower oil, olive oil, monoacylglycerols.

The methods used in the work are as follows: drying of fresh walnut leaves; extraction of antioxidant substances from walnut leaves and calendula flowers. The used method is the calculation of the solids content in the extracts. The method of determining the quality of oils by acid, peroxide numbers, as well as by induction periods is applied. A full factorial experiment was performed. Cleaning of oils from tocopherols is produced. The oxidation rate was investigated and the results obtained on a volumetric installation were processed. The oxidation rate and the magnitude of the induction periods were investigated, and the results obtained on the Oxy test device were processed. Chromatography to determine the fatty acid composition of the oils was performed. A method has been developed for the introduction of an aqueous-alcoholic extract, saturated with antioxidants, into oil.

3. Results

After studying the chemical composition of various plants and assessing their value, plant sources were selected for the preparation of antioxidants. These sources were walnut leaves and calendula flowers. Walnut leaves are rich in

antioxidant substances such as: flavonols, catechins, caffeic acid, gallic acid, cinnamic acid, salicylic acid, rutin, quercetin, chlorogenic acid, ellagic acid, vanillic acid, ferulic acid. Calendula flowers contain in their composition: sterols, polysaccharides, polyphenols, resins, organic acids, essential oils, carotenoids, flavonoids, phytoncides, saponins, triterpenoids, trace elements and macronutrients. Consequently, these plants are well suited for our purposes, since they contain many antioxidants, and also have a low cost, which will make our antioxidant able to compete in value not only with plant but also with synthetic antioxidants. Walnut leaves and calendula flowers are allowed for use in food [13, 14], because antioxidants produced from them will be safe for health, subject to the recommended doses.

At the next stage of the work, the extraction parameters were selected for the extraction of antioxidants from selected plant materials [15]. Studies have shown that the following parameters are optimal conditions for the extraction of antioxidant substances from walnut leaves. Extraction temperature – 68 °C. The ratio of the extracted raw materials: solvent =1:20. The frequency of rotation of the mixer – 60–120 revolutions per minute. Extraction time – 20 minutes. The solvent is water-alcohol with an ethanol concentration of 70 %. The antioxidant properties of the resulting extract were evaluated for their ability to slow down the oxidation of oil containing essential fatty acids. The ability to slow down the oxidation processes was illustrated by a change in the oxidation rate, as well as an increase in the induction period.

The next stage of the work is the development of a complex antioxidant from walnut leaves and calendula flowers with the study of the synergism of their antioxidant substances, as well as joint synergism with vitamin E, which is a strong natural antioxidant [16].

To study synergies, a full factorial experiment was designed with three parameters that were subject to variation. These parameters were: the content of tocopherols in the refined sunflower oil; the concentration of walnut leaf extract in the mixture that was to be oxidized; the concentration of calendula flower extract in the mixture that was to be oxidized. The oxidation of the samples was carried out on the Oxy test device. The output parameter of this full factorial experiment is the induction period of sunflower oil.

The planning matrix of the experiment is given in **Table 1**, in which x_1 – the content of tocopherols in refined sunflower oil (from 10 to 75), mg/100 g; x_2 – the concentration of walnut extract (from 2.5 to 10),%; x_3 – the concentration of calendula flower extract (from 0 to 2.5),%; Y_{av} – the average value of the induction period, obtained by processing the results of parallel experiments, minutes.

The greater the value of the induction period, the higher the strength of the developed antioxidant.

A control experiment was also carried out – oxidation of sunflower oil without the addition of extract. The induction period of the control experiment was 1426 minutes.

The processing of the obtained results according to the compiled plan of the full factorial experiment was conducted in the environment of the MathCad package.

Let's consider the optimum addition of walnut extract in the amount of 2.5 % together with the extract of calendula flowers in the amount of 2.5 %, since in this case the antioxidant power of the complex antioxidant is 2855/1426=2. The resulting figure is sufficient to maintain the quality of the product at the proper level.

Table 1

Experiment planning matrix

No. of experiment	x_1, mg/100g	x_2, %	x_3, %	Y_{av}, min
1	10	2,5	0	214,15
2	10	2,5	2,5	224,5
3	10	10	0	233
4	10	10	2,5	250,5
5	75	2,5	0	2675
6	75	2,5	2,5	2855
7	75	10	0	3129
8	75	10	2,5	3369

Synergism between antioxidant substances from extracts of walnut leaves, calendula flowers and tocopherols is proved. In this research, we proved the ability of the developed plant antioxidant to exert an antioxidant effect against fatty acids of different composition, which allows its use in a wide range of products [17]. It is proved that the developed antioxidant is able to slow down the oxidation process at the level of the popular antioxidants that are now used in industry. A technological scheme for stabilizing vegetable oils with a complex antioxidant has been proposed [3, 18].

4. Discussion of results

The obtained results allow to conclude about the feasibility of using the developed antioxidant in the industry, due to its high efficiency. This antioxidant is recommended for use in industry to protect against oxidation of vegetable oils, fats and fat-containing products. Athletes are advised to eat foods stabilized with a developed antioxidant from walnut leaves and calendula flowers for the following reasons:

1) antioxidant keeps the quality of the product at the proper level;

2) product contains safe plant antioxidants;

3) antioxidants give the product additional nutritional value.

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